Recent Evidence for Continental Shelf Methane Clathrate Instability and Proposed Emergency Plan for NASA to Monitor for Tropospheric Methane Above Continental Shelves Globally

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Where We Left Off

- In October, 2008, I presented my first presentation on the subject of the critical need for tropospheric methane monitoring of the globe, especially along the edges of continental shelves (at the continental slope) and in tundra regions, ending with the following slide:

What Should We Do?

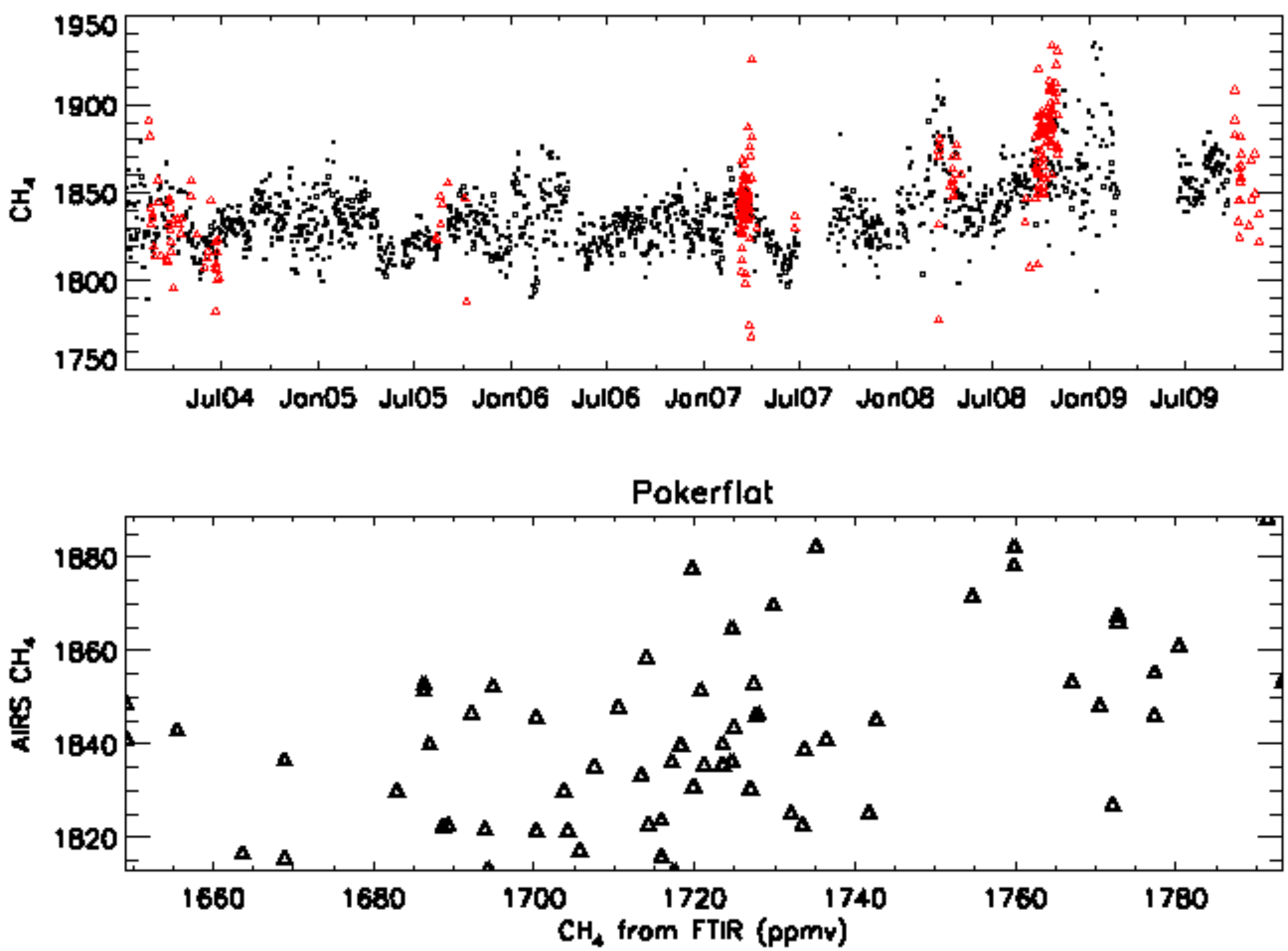
- Search the existing AIRS data for the reflective IR band and the 7.7 micrometer band for evidence of methane at known geological sites of great methane escape.
  - If that is positive, look for methane in those images at the continental slopes and tundra regions.
- We need to try the 3.314 micrometer band and at least one nearby band for methane imaging from space.
- The future habitability of our planet may depend on how well and how soon we can map methane from space.

What Has Happened Since

- Two talks after mine at the AIRS meeting in Oct., 2008 (Greenbelt, MD), Leonid Yurganov (UMBC) presented a paper that showed AIRS detection of increased methane escape from tundra regions in Siberia in recent years.
  - He used a reflective infrared absorption band of methane, which is better for methane seeps over land than for off-shore seeps.

What Has Happened Since (Continued 1)

- Xiaozhen (Shawn) Xiong and another scientist has started comparing AIRS methane results (using the 7.7μm methane absorption band) with FTIR ground-measured methane measurements over Poker Flats, Alaska
- Early results of that effort are shown in the next slide

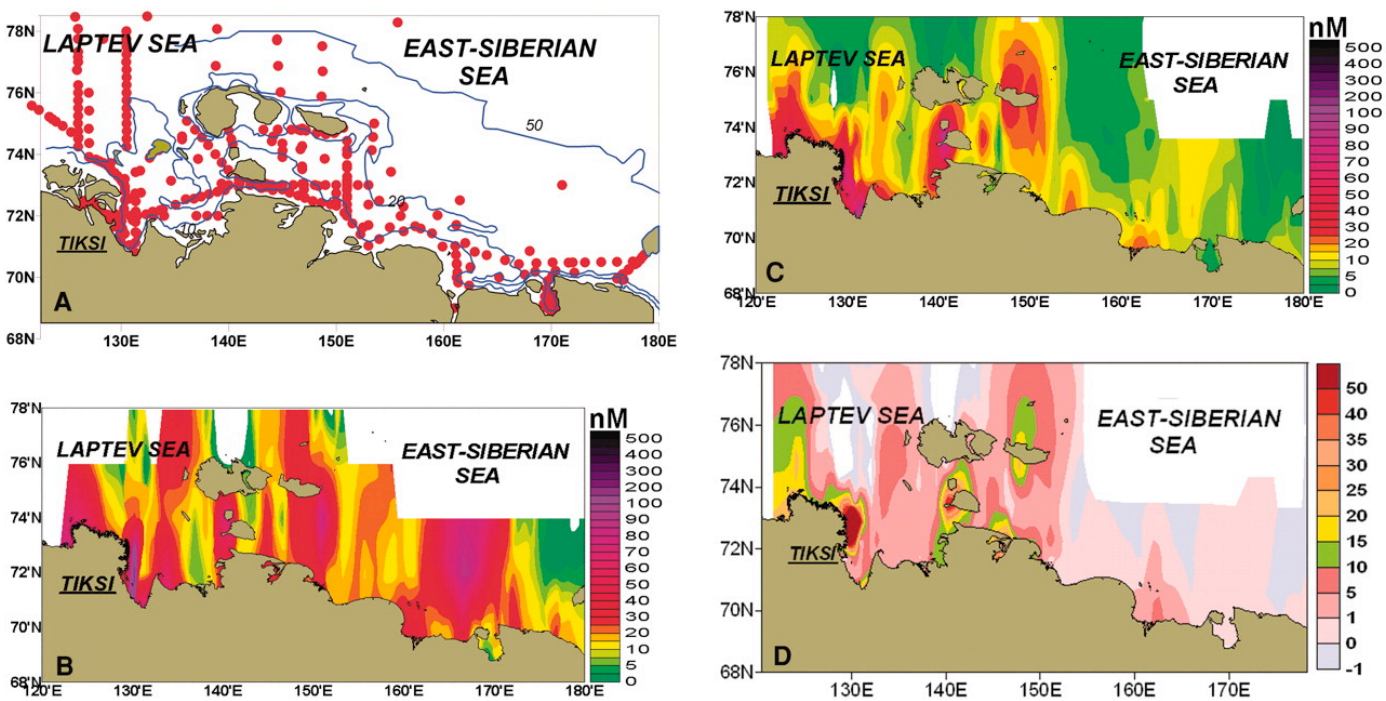


1950
1900
1850
1800
1750
CH4
Jul04
Jan05
Jul05
Jan06
Jul06
Jan07
Jul07
Jan08
Jul08
Jan09
Jul09
Pokerflat
1880
1860
1840
1820
AIRS CH4
1660
1680
1700
1720
1740
1760
1780
CH4 from FTIR (ppmv)

What Has Happened Since (Continued 2)

- The March 5, 2010 issue of <u>Science</u> (Vol. 327, pp. 1246-1250 by Natalia Shakhova, Igor Semiletov, Anatoly Salyuk, Vladimir Yusupov, Denis Kosmach, and Orjan Gustafsson, “Extensive Methane Venting to the Atmosphere from Sediments of the East Siberian Arctic Shelf” found from over 5,000 at-sea observations that <u>over the East Siberian Arctic Shelf (ESAS), >50% of surface waters and >80% of bottom waters are supersaturated with methane.</u>
- The quantity of methane venting over ESAS is on a par with previous estimates of methane venting from all of the world’s oceans.

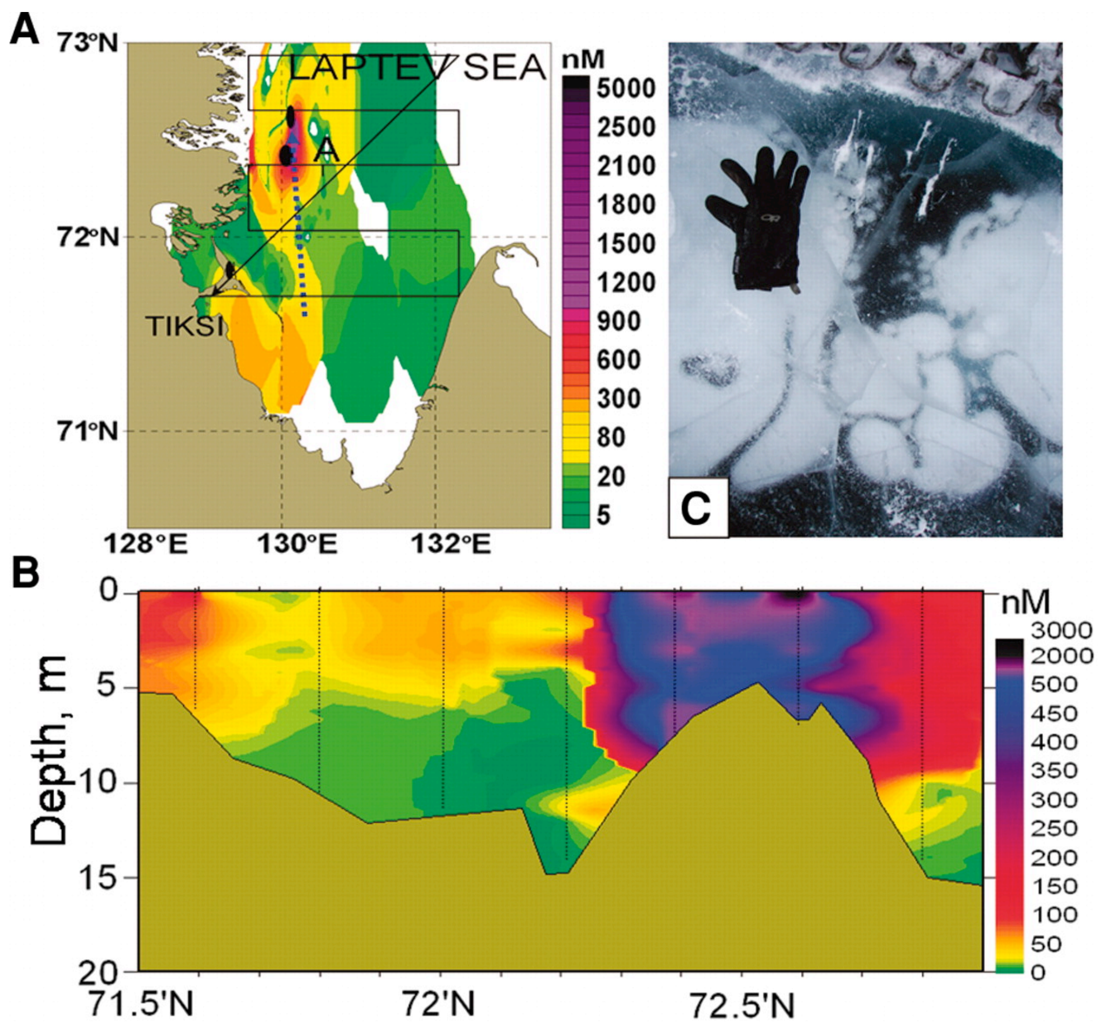
Fig. 1 Summertime observations of dissolved CH4 in the ESAS (21)



N. Shakhova et al., Science 327, 1246-1250 (2010)

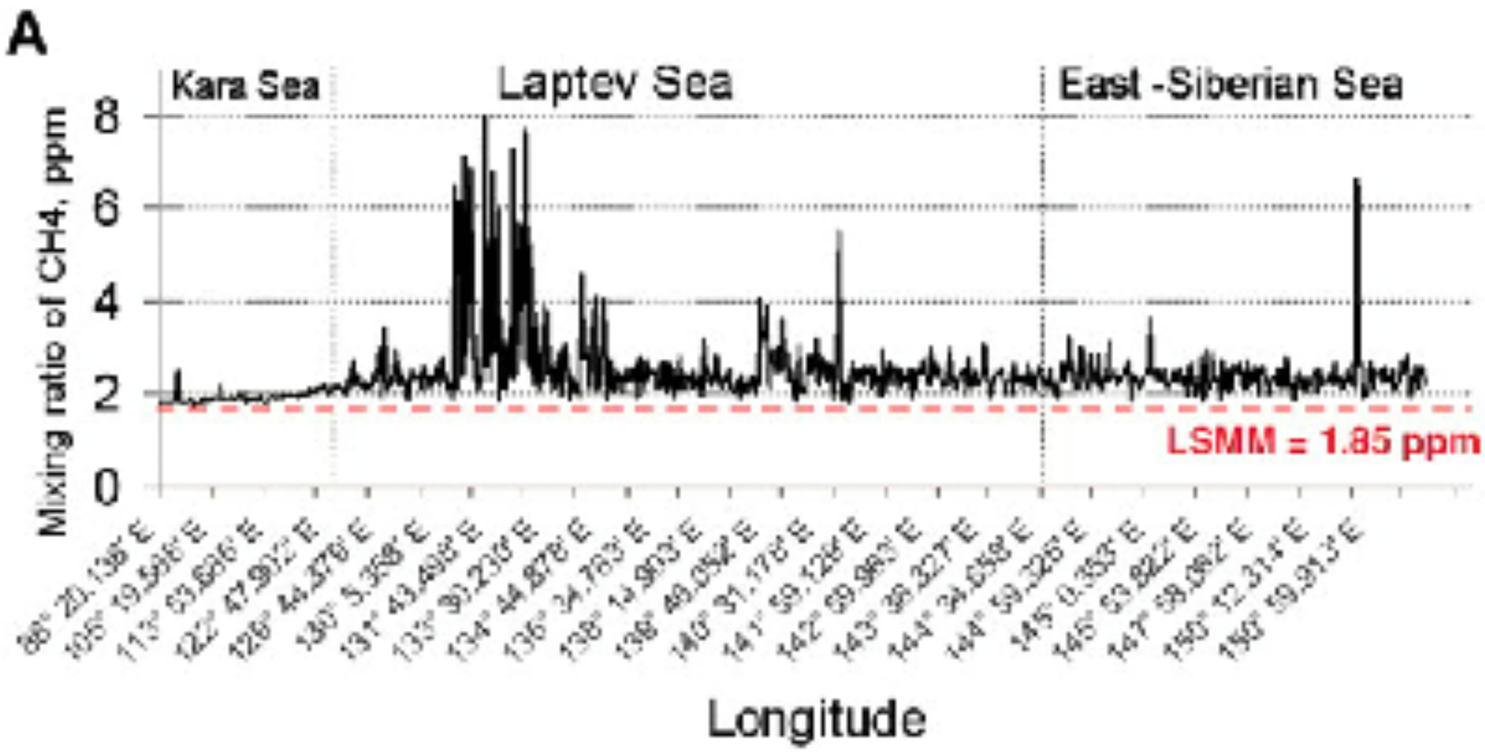
Published by AAAS

Fig. 2 Wintertime observations of dissolved CH4 in the ESAS (21)

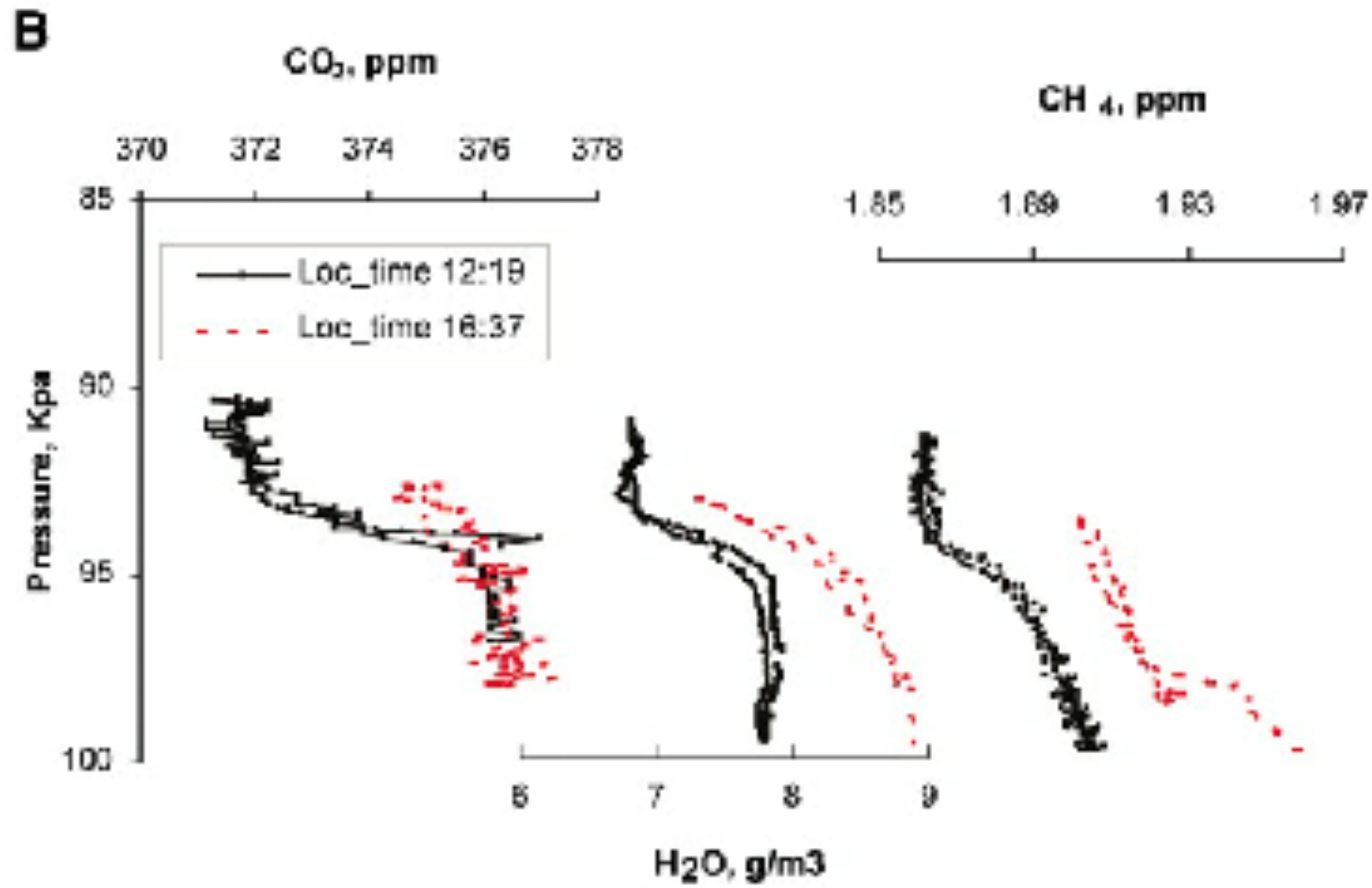


N. Shakhova et al., Science 327, 1246-1250 (2010)

Methane Mixing Ratio in Atmospheric Boundary Layer



Vertical Mixing Ratio of Methane (Helicopter) in the Atmosphere, Sept., 2006, SE Laptev Sea



Last Sentence of Shakhova et al's Science Paper

- "To discern whether this extensive CH4 venting over the ESAS is a steadily ongoing phenomenon or signals the start of a more massive CH4 release period, there is an urgent need for expanded multifaceted investigations into these inaccessible but climate-sensitive shelf seas north of Siberia."

A Special NASA/NOAA Project Is Needed to Develop and Employ An Atmospheric Methane Remote Sensing Capability for Continental Shelves and Tundra Regions

- Part I of the project would be extensions of what AIRS has already developed regarding CH_4 and CO, which is a product of CH_4 oxidation
- Part 2 would be an aircraft program would be added to test how well the AIRS methods are working and to test new spectral bands and active imaging methods for CH_4 and CO
- Part 3 and final phase of the project would be to operationally map atmospheric CH_4 and CO for all the world's continental shelves and tundra regions with the methods from Parts 1 and 2

Part 1: Extending What AIRS Has Already Done for CH_4 and CO

- A archival study needs to be done immediately with the 7.7 µm absorption band of methane applied to the continental shelf above East Siberia, from where the recent Russian data came.
  - The same needs to be done in the same place with the CO AIRS method
- Follow that with an archival AIRS study of the continental slopes above Alaska and the eastern seaboard
- Then do the Canadian arctic and other continental shelves

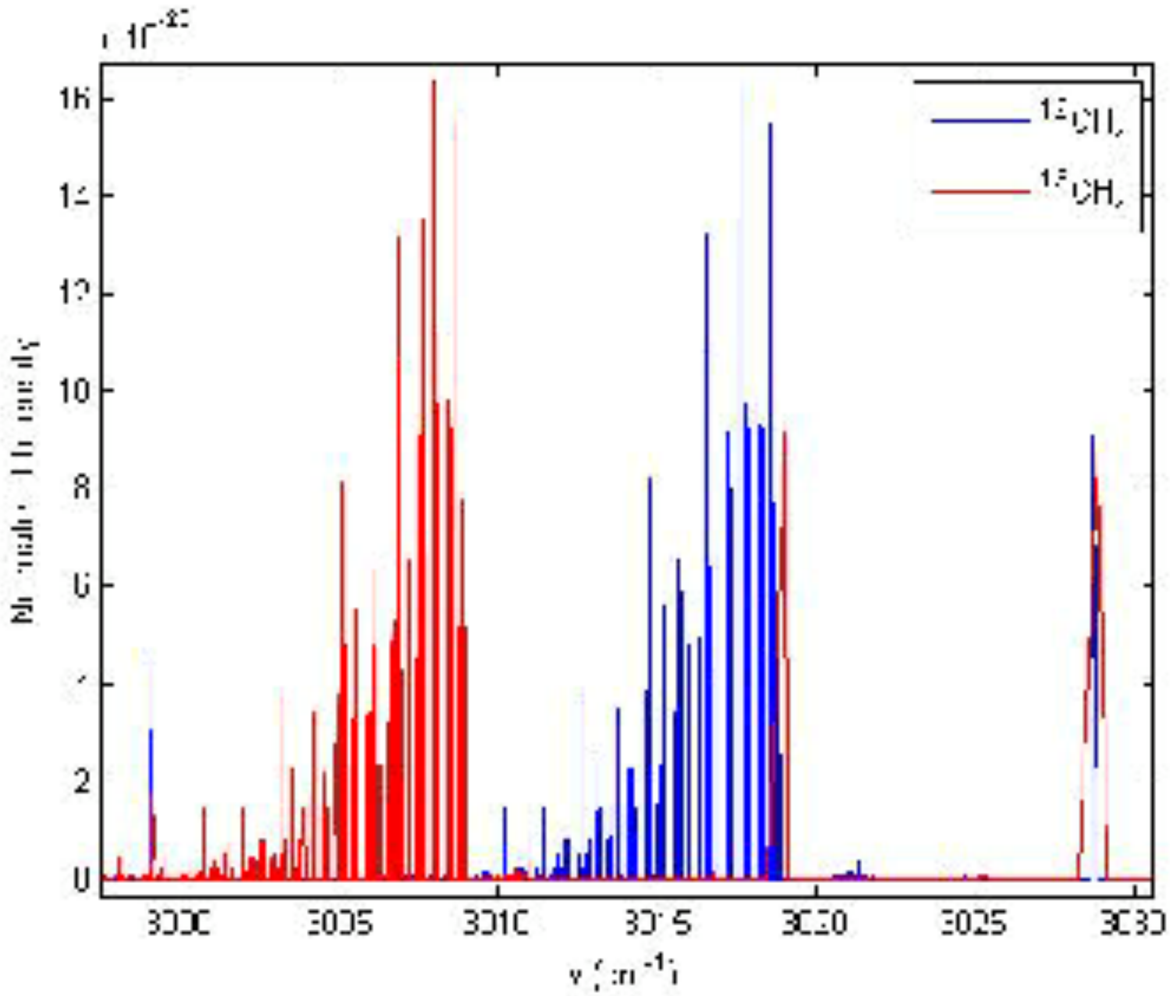
Part 2: Create An Experimental Aircraft Program for Mapping CH_4 and CO

- Obtain airborne hyperspectral data during overpasses of the AIRS sensor to compare the same data processing methods measured from space and from the upper Troposphere
- Experiment with both AIRS bands and with bands in the 3-5 micrometer and other wavelength regions not covered by AIRS
- Experiment with active hyperspectral remote sensing methods from aircraft
- Experiment with different spatial resolutions to find an optimal one for mapping new methane and carbon monoxide seeps into the atmosphere

It May Be Possible to Map the Isotopic Ratios of Carbon in Methane by Hyperspectral Remote Sensing

- An airborne program using lasers might be able to tell the difference between CH_4 with C^{12} versus C^{13} in it
  - This would help determine whether the methane was mostly from fossil methane (natural gas) or from decay of recent organic matter
  - The next slide shows where the absorption bands are located for methane of the two isotopic types of carbon

Different Absorption Bands for Methane for C13 (Red) vs. C12 (Blue) Isotopic Ratios (from HITRAN) in the 3000-3020 cm-1 Frequency Region (3.33-3.31 μm Wavelength Range)



Why Do We Need Quantitative CH_4 and CO Imaging?

- To determine where mitigation efforts against methane escape to the atmosphere are most needed
- To track whether mitigation efforts are working or not

What Kind of Mitigation for Methane Clathrate Destabilization Might Work?

- Drill the continental shelves landward of the methane/carbon monoxide seeps, with several horizontally drilled holes from each vertical hole
- Build oil and gas pipelines from the mitigation wells to the nearest onshore markets
  - This requires drilling in deeper waters than normal, but there are several nations with large petroleum companies that can do it
  - Stop the program if remote sensing shows that the CH_4 and CO emissions are not decreasing in time

What Are the Risks?

- If mapping CH_4 and CO on the continental shelves and tundra regions show that these two gases are increasing in time we USE the methane with a mitigation plan, or LOSE it to the atmosphere
  - If we lose it to the atmosphere, it will cost great sums of money to mitigate the much increased global temperatures, perhaps 10`F or more, over a few decades
  - If we use it for energy, the market will fund it

Remote Sensing is Important for This Complex Problem

- As with sea surface temperatures, remote sensing produces far higher spatial resolution data than in situ water sampling can produce, at much less cost.
  - The in situ sampling can still be done to check the remote sensing results, but on a sparse-net basis (not many samples per 100 km^2)
- The remote sensing results are needed to show where to drill, and whether the drilling has succeeded in slowing CH_4 and CO seeps into the atmosphere

If NASA and NOAA Do Not Tackle the Remote Sensing Part of This Problem, Who Will?

- The most likely answer is “Nobody”
- It must be a focused project to succeed
- It must be started very soon to succeed